Exposure to airborne fungi and bacteria in Brisbane houses after the 2011 flood

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1 Introduction

A series of flooding events occurred in Queensland, Australia during December 2010 and January 2011. The state's capital city of Brisbane experienced major flooding in January 2011, when the Brisbane River broke its bank and inundated low lying areas.

Stagnant water and wet building materials are a breeding ground for microorganisms, such as viruses, bacteria, and fungi, and these can cause disease, trigger allergic reactions and continue to damage materials long after the flood (EPA, 2003). Therefore, swift action to remove wet materials and dry out the building structures can help to reduce moisture and humidity in flooded houses, in an effort to prevent the growth of bacteria and mould.

The aim of the present study was to quantify the effect of flooding on fungal and bacterial concentrations, as well as fungal species, in the indoor air of flooded houses. The hypothesis was that, based on the swift removal of wet materials, together with the cleaning and drying of the building structure, fungal and bacterial concentrations were not expected to be significantly higher than normal background concentrations in the flooded area.

2 Materials/Methods

Air samples from flooded and non-flooded control houses were drawn from several suburbs in Brisbane. The selected houses contained a wide cross-section of building materials and styles: new-old, brick-timber, high set-low set etc.

Different types of indoor and outdoor particle measurements were conducted in 25 flooded and 16 non-flooded houses between March and May 2011. This paper present results of culturable fungal and bacterial measurements.

Culturable fungi and bacteria were assessed using a Biotest RCS HIGH FLOW Air with 20 L or 50 L sampling for fungi and 100 L sampling for bacteria. Altogether six fungal and six bacterial samples were collected in each house (three from the living room and three from the bedroom) and three fungal and bacterial samples were collected at the outdoor control site.

Rose bengal agar strips were used for fungal culture and incubated at 28 °C for four days to permit quantification and seven days to partial identification. Partial identification included *Penicillium*, *Cladosporium* and *Aspergillus* as the three dominant genera, identified to genus level only. In addition, the total number of fungal colonies was determined.

For bacterial isolation, Tryptic soy agar strips were used and incubated at 32 °C for three to four days to permit quantification. Fungal and bacterial numbers were expressed in terms of colony-forming units per cubic meter of air (CFU/ m^3).

3 Results

The arithmetic mean fungal concentration in indoor and outdoor air was 1051 cfu/m^3 and 1355 cfu/m^3 for flooded houses, and 614 cfu/m^3 and 797 cfu/m^3 for non-flooded houses, respectively. The median concentration of fungi in indoor and outdoor air was 881 cfu/m^3 and 863 cfu/m^3 for flooded houses, and 547 cfu/m^3 and 640 cfu/m^3 for non-flooded houses, respectively.

The most frequently isolated fungal genus from the indoor air, in both flooded and non-flooded houses, was *Penicillium* (flooded houses – 33 %; non-flooded houses – 34%), followed by *Cladosporium* (flooded houses – 30%; non-flooded houses – 21%). In outdoor air, the prevalent fungal genus for flooded houses was *Cladosporium* (33%), while for non-flooded houses the occurrence of *Cladosporium* (25%) and *Penicillium* (25%) was equal. The occurrence of *Aspergillus* was much lower both in indoor (flooded houses and non-flooded houses: 5%) and outdoor (flooded houses: 9 %; non-flooded houses: 4%) air. The occurrence of other fungi in indoor and outdoor was higher in non-flooded houses (41% and 47%) than in flooded houses (32% and 32%).

The arithmetic mean bacterial concentration in indoor and outdoor air was 200 cfu/m^3 and 122 cfu/m^3 for flooded houses, and 202 cfu/m^3 and 86 cfu/m^3 for non-flooded houses, respectively. The median concentration of bacteria in indoor and outdoor air was 172 cfu/m^3 and 95 cfu/m^3 for flooded houses, and 178 cfu/m^3 and 83 cfu/m^3 for non-flooded houses, respectively.

4 Discussion

Although airborne fungal concentration (arithmetic mean and median) was generally higher in flooded houses than in non-flooded houses, fungal concentrations varied extensively between both in flooded and non-flooded houses, as well as between outdoor areas.

In the majority of flooded, as well as non-flooded houses, the WHO guideline value of 500 CFU/m^3 (WHO, 1990) for fungi was exceeded. However, background fungal concentrations in the Brisbane area were shown to exceed 1000 cfu/m^3 in the past, in the absence of any flooding (Hargreaves, et al. 2003). This implies that the fungal concentrations measured after the flooding event were not particularly higher than the usual background levels. In contrast to this, fungal concentration after the New Orleans floods in 2005 were found to exceed 50000 cfu/m^3 (Solomon, et al. 2006), which is significantly higher than the post-flood levels observed in this study.

The indoor air mycoflora largely reflected the fungal flora present in the outdoor air. Our study agrees with previous studies, in that *Cladosporium* was the dominant genus in outdoor air – a result that has been found around the world during all seasons (WHO, 2009). Our study also supports earlier findings that the common indoor air fungi, *Penicillium*, can easily grow on wet material, and thus, it is the most common fungal genus detected in moisture damaged areas (Hyvärinen et al. 2002).

In this study, bacterial concentration was similar in flooded and non-flooded houses. The main sources of bacteria in the indoor environment are outdoor air, people and indoor bacterial growth (WHO, 2009).

5 Conclusions

This study showed that, as expected, the difference in fungi concentration between flooded and non-flooded houses was only minor. This supports our hypothesis that the swift removal of wet materials and the drying out of building structures soon after the flood help to reduce moisture and humidity in flooded houses. In addition, there was no significant difference between the concentration of bacteria in flooded and non-flooded houses. Ongoing data analysis will aim to identify if there are any after-flood cleaning and drying techniques which are more efficient than others.

6 References

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